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Coordinated Action in 3-D Space

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Prepared in cooperation with Dr. Eileen Kowler

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13. ABSTRACT (Maximum 200 words)

This grant 1) tests alternative hypotheses about mechanisms controlling gaze-shifts while manipulating nearby objects, viz., on-line feedback vs. learned, preplanned coordinated movements and 2) studies speed and accuracy of visually-guided arm movements. Work this year concentrated primarily on instrumentation, i.e., a) a SUN workstation was procured and configured, b) an interface between the Maryland RFM and a PC was constructed. This allowed old DEC computers to be retired, c) a hands-on, calibrated workspace was constructed and d) software for data acquisition and analysis was developed.

Progress was made with more intellectual activities while this new instrumentation was developed, viz., a) a behavioral trigonometric technique was worked out for estimating the eyes's centers of rotation with the head free to move, b) slow control was shown to be sensitive only to velocity and not to position (contrary to prior claims), c) Pizlo completed a Ph.D thesis on shape constancy by human beings and computers, and d) it was shown that unspaced word-texts could be read out-loud easily. This provocative finding makes great difficulties for all contemporary theories of reading because they assume that spaces in texts are required to parse words effectively.

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Coordinated Action in 3-D Space**PI: Robert M. Steinman****Annual Report**

Research Objectives: The primary current concerns of this grant are 1): testing alternative hypotheses about the mechanisms that control gaze-shifts associated with manipulating nearby objects, namely, on-line feedback vs. learned, preplanned coordinated movements and 2) studying the accuracy of arm movements made to targets in nearby 3-D space. At the present time we are completing development of the instrumentation and software to collect and analyze data relevant to these concerns. Much progress was made with both instrumentation and software during the first year of the grant and the research plan is proceeding on schedule.

Summary of Activities: Much effort during this period was directed to hardware modifications and software development to permit the best possible study of coordinated action in 3-D space. Specifically:

a) A SUN SparcWorkstation 2 GS was procured and configured for analyzing eye and head movement data. This was done primarily by Eugene Day (the SUN faculty guru in the EE dept). Our SUN system UNIX software finally seems to be configured in a manner appropriate for use with many of our current and future requirements.

b) An interface between the Maryland RFM with its translation measuring accessory and an IBM PC AT (provided by my dept) was designed and constructed by our Physics Electronics Development Group. This interface serves 2 functions, namely, 1) it allows us to retire our antiquated DEC acquisition and analysis machines with their high maintenance costs (my dept maintains the new PC front end for the SUN, which is our service responsibility) and 2) it provides common media for Kowler on 1.44 Mb diskettes that she can use to analyze our collaborative data on her IBM 2/80 (the common medium for the Collewyn group will be via 150 Mb tapes in a UNIX tar format that can be read by his SILICON GRAPHICS IRISs).

c) Data acquisition and experimental control software (TURBO C++) has been developed by M. Fritz, who developed the original FORTRAN and DEC assembly software for my PDP 11/24 and 11/73 machines. Fritz, in collaboration with our Physics Electronics Group, finished the prototype of an elaborate hands-on-workspace that subjects will use to perform visually-guided motor tasks.

d) Eye movement plotting and analysis programs were developed for use on both our PCs and the SUN by J. Epelboim. She has made a good start on a basic package, which includes saccade detection and measurement and PostScript routines for plotting eye movement records and analyses on the SUN. We expect to have a reasonable analysis capability when our visitors come to do collaborative research next May-June.

Effort was also expended on intellectually more creative areas while the activities described above were ongoing. Specifically,

a) Pizlo and Epelboim worked out a behavioral technique for estimating the centers of rotation of the subject's eyes when the head is held on a biteboard and when it is free to move. This novel technique offers the promise of being able to measure the directions of the lines of sight in space, when the head is free, with accuracy and precision as good as careful fixation with the head fixed, i.e., good to 2 or 3 minarc. Furthermore, the new technique fits quite naturally into a typical protocol for collecting eye and head movement data while the subject performs visually-guided motor tasks. This means that we will not have to devote about half of the available silicone annulus wearing time to indirect measurements, such as measuring the sparker's position on a biteboard before mounting it on the subject's head as we were forced to do in our prior free-head work. Preliminary tests of our new technique have been promising and

a full-scale test will be made as soon as the hands-on-workspace (with software) has been implemented in the lab. We need the accuracy and repeatability for target placement incorporated in the recently completed hands-on-workspace to test our new calibration technique adequately.

b) The activities described so far represent the main progress with work directly related to the grant. Other projects were also completed during the same period. Specifically,

- 1) Epelboim, collaborating closely with Kowler as well as myself, has completed a series of experiments, showing quite clearly that the low velocity oculomotor control subsystem (slow control) is not position sensitive and seems, therefore, to be responsible for minimizing drift velocity exclusively (contrary to claims that have been made). This work will satisfy Epelboim's "masters or research competency" requirement. A ms describing this work nears completion and should be submitted soon (probably to Vision Research). A partial report of this work had already been made at ARVO.

- 2) Pizlo completed his Ph.D thesis on shape constancy during this period, describing portions of this work both at ARVO and at the annual meeting of the Mathematical Psychology Society. Pizlo has continued to collaborate (at no cost) on the grant project since joining the Department of Psychological Sciences at Purdue U. in August and we look forward to his continuing to collaborate because he has made major contributions to our research to date.

- 3) I, in collaboration with Epelboim and Booth (a cognitive graduate student and Airey (an undergraduate honors student), have been working on reading research during our spare time while waiting for the hardware and software development described above. I discovered in the course of light reading during one of my numerous AMTRAK commutes that prior to about 900 AD texts did not contain spaces between words and decided to look at reading with both spaced and unspaced texts in the lab because I suspect that the ancients were able to read such unspaced texts easily. If not, spaces surely would have appeared in texts much earlier because spaces are much easier to chisel than words and stone was plentiful in the ancient world (see, for example the Rosetta Stone which contains no word-spaces in any of the 3 languages it contains). It should be noted that all contemporary theories of reading are based on, more or less important, "optimal viewing positions" within words set off by spaces in text. We are finding that the ancients probably had little, if any, difficulty reading their unspaced texts. An abstract on reading spaced and unspaced text was accepted for presentation at ARVO in May 1992 and Julie Epelboim (the first author) was awarded a travel grant to permit her to present this material at the meeting. We probably will also submit something on this topic to next year's Psychonomic Meeting. I have made oculomotor waves in the past, but this new stuff is a veritable flood and fun to do as well.

- 4) Collewyn visited with us (Steinman, Kowler, Pizlo and Epelboim) for a week in July (at his expense) at which time we completed detailed plans for the book on oculomotor control we are committed to write for SINAUER. We also discussed in detail our plans for analyzing data collected during Collewyn and Erkelens' last visit to Maryland and to plan specific experiments to get ready for the next visit scheduled for this coming Spring. We agreed that we should not try to do further analyses of the "old" data collected with the head free because we did not appreciate the importance of head torsions when these data were collected and inaccuracies could arise either from the oculomotor system or from demands introduced by an unknown head torsion (demonstrated accuracy is no problem but inaccuracies could arise either from properties of the oculomotor system or from unmeasured components of head motion). We decided instead to add the required additional orthogonal head coil to the RFM and to collect new free-head data which could be analyzed with no remaining ambiguity rather than to spend more time analyzing potentially ambiguous recordings made 3 years ago.

We all felt that we had gotten as much out of our prior measurements as could be done convincingly and that all subsequent analyses of "old" data would be confined to conditions in which the head had been stabilized. This left one important set of measurements showing that vergence cannot be changed with truly isovergent target placements. In essence, the target has to be seen as located in 3-D space before vergence changes can be made. Currently, Collewyn is writing up this material for publication and I expect him to bring a draft with him for us to complete together when he comes to work with the Maryland RFM during his upcoming May/June visit. It was the conference last July (described just above) which encouraged me to concentrate on developing the new hardware-software in Maryland so as to have it ready before the collaborators' extended visit was firmly committed -- a visit that will bring Collewyn, Van den Berg, Erkelens, Pizlo and Kowler to the lab in Maryland to collect a new, and undoubtedly enormous mountain of data.

Articles planned, nearing completion and to be published:

Epelboim and Kowler E. (in prep.) Slow control is driven by velocity, not position, signals. Will be submitted to Vision Research by May 1992.

Epelboim, J., Airey, J., Booth, J. and Steinman, R. (in prep.) Reading unspaced text. Will be submitted to Vision Research or Perception & Psychophysics by or before January 1993.

Pizlo, Z. (in prep.) Shape constancy in human beings and computers based on a perspective invariant. Will be submitted to the Psychological Review by or before January 1993.

Pizlo, Z. and Rosenfeld, A. (in press) Recognition of planar shapes from perspective images using contour-based invariants. Computer Vision, Graphics and Image Processing: Image Understanding.

Participating Professionals:

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	Received Ph.D. in Psychology, August 1991, Title:
	Shape constancy in human beings and computers based on a perspective invariant
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J. Van der Steen	Res. Scientist, Erasmus U. Rotterdam
Julie Epelboim	Graduate Research Assistant UMCP

Papers at Meetings:

R. Steinman, H. Collewyn, E. Kowler, C. Erkelens, Z. Pizlo and J. Van der Steen (1991) Free-headed gaze-shifts between nearby targets are accurate. ARVO Meeting. Abs. published in Invest. Ophthal. & Visual Sci., 32, 1021.

Z. Pizlo, A. Rosenfeld and J. Epelboim (1991) Speed-accuracy tradeoff in a spatial-interval identification task. ARVO Meeting. Abs. published in Invest. Ophthal. & Visual Sci., 32, 1272.



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